STAFF REPORT

GENERAL INFORMATION REGARDING POTENTIAL WATER QUALITY IMPACTS OF AQUIFER STORAGE AND RECOVERY PROJECTS

Issue

Aquifer Storage and Recovery (ASR) projects are being considered by a number of municipalities to increase their drinking water supplies by pumping water underground in times of abundant supply and extracting water from the same aquifer in times of need. In contrast to other types of conjunctive use projects, ASR projects utilize treated drinking water as the type of water injected into the aquifer. Due to constituents present in the raw source water and disinfection byproducts formed during chlorine disinfection, the injected drinking water may contain chemical constituents in concentrations that violate one or more water quality objectives for groundwater. This staff report describes the policy and regulatory issues and provides recommendations for the regulation of this type of activity.

Discussion

There are two general types of systems for conjunctive use of surface water and groundwater. One involves the use of spreading basins to percolate water through the soil and into the aquifer. The other uses one or more wells that both inject and extract water; these projects are referred to as aquifer storage and recovery (ASR) systems. Long-term implementation of ASR projects are designed and operated to inject water into the aquifer during times when water supplies are plentiful and to extract water when needed to augment domestic/municipal water supplies. As compared to a spreading basin, direct injection does not need a large area of land, and loss of water through evaporation is prevented. However, with direct injection into the aquifer, there is no soil mantle to provide attenuation or treatment before any constituents of concern enter the groundwater.

Benefits of ASR Projects

There is increasing demand for water supplies due to current and projected population growth. Environmental concerns have restricted the building of dams and reservoirs to store natural runoff available during the wet season to extend the temporal availability of this water through the dry, summer season. So alternatives are certainly necessary. Storing abundant winter runoff in existing groundwater aquifers has emerged as one of the more environmentally acceptable alternatives, and in fact, both the California Bay-Delta Authority and the California Department of Water Resources recommend ASR technology and provide grant funding for these projects.

Groundwater Quality Impacts

Even though injected water may meet all current drinking water standards, chemicals may be present in excess of water quality objectives that apply to groundwater. Degradation and pollution of groundwater resources could result from inadequately regulated ASR projects. Many communities throughout the State are solely dependent on groundwater as their source of supply for domestic and agricultural uses. To protect groundwater from pollution and unreasonable water quality degradation, the Regional Board must assure that projects that store surface water in groundwater aquifers do not significantly degrade the quality of the water available for subsequent extraction and use. ASR project water may contain significant concentrations of chlorine disinfection byproducts – including trihalomethanes (THMs), haloacetic acids (HAAs), nitrosodimethylamine (NDMA) – as well as pollutants present in raw source waters due to upstream point and non-point discharges – including salts, metals, pesticides, pharmaceuticals, and endocrine disruptors. Discharge of such waste constituents could violate water quality objectives in the Basin Plan.

Maximum Contaminant Levels versus Health-Based Limits

Drinking water standards (Maximum Contaminant Levels or MCLs) apply to domestic/municipal water supplies, but may not be sufficiently stringent to protect beneficial uses of groundwater resources. Several water quality objectives that apply to groundwater in the Central Valley Region are more stringent than MCLs. The MCLs for two categories of disinfection byproducts, THMs and HAAs, are significantly higher than health-based limits for the individual chemicals in these classes. As such, these MCLs are not fully health protective. Most municipal drinking water systems disinfect with chlorine and there are costs associated with converting to other disinfection methods. For this reason, the MCLs for THMs and HAAs were derived by balancing the benefit provided by chlorination – elimination of pathogens in drinking water – with the health threats posed by the disinfection by-products. These MCLs accept some cancer risk in order to eliminate the health risk from pathogens and avoid costs of converting to other disinfection processes. However, in the case of groundwater protection, this balancing is normally not germane. Most groundwater is pathogen free. No chlorination is necessary to allow domestic consumption. Therefore, it may not be reasonable to accept the cancer risk posed by disinfection byproducts when there are no pathogens to remove. Application of the narrative toxicity objective in the Basin Plans requires more stringent limits than MCLs for THMs and HAAs in groundwater.

The California Department of Health Services (DHS) and the USEPA set MCLs no lower than commonly-achievable analytical quantitation limits, even when health concerns exist at these levels. MCLs for several chlorinated solvents, including TCE and carbon tetrachloride, have been set in this manner. Since these MCLs were adopted, analytical quantitation limits have improved significantly. Concentrations in water equal to the health-based limits for these chemicals can now be reliably measured at reasonable cost. Therefore, the technological constraint that drove setting the MCLs for these chemicals it is no longer germane.

Recent legislation requires DHS to periodically review California MCLs and to revise them to be as close to purely health-based limits as is technologically and economically achievable. So, compliance with health-based limits in groundwater, consistent with the narrative toxicity objective in our Basin Plans, also addresses compliance with probable future MCLs.

There are additional circumstances where water quality limits more stringent than MCLs are applied to protect beneficial uses of groundwater. The yield of sensitive crops can be reduced by concentrations of chloride, boron and salt that are below their respective MCLs. For this reason, agricultural use-protective limits for several constituents and parameters are commonly used by the Board to protect agricultural uses of groundwater. Many chemicals cause water to taste or smell bad at concentrations lower than MCLs; for example, the taste-and-odor threshold for xylene is 17 ug/l as compared to its MCL of 1,750 ug/l. For this chemical as well as others, water is rendered unpalatable, and beneficial uses are impaired, even at concentrations that are significantly lower than MCLs. The narrative water quality objective for tastes and odors is commonly used to prevent such impairment. In summary, MCLs may not sufficiently protect the most sensitive beneficial uses of groundwater.

Adsorption or Degradation in the Aquifer

ASR project proponents have produced papers from conference proceedings that indicate possible adsorption or degradation of THMs and HAAs in the subsurface after injection. They indicate that upon extracting the water, these disinfection byproducts are not found in the recovered water. It is

hypothesized that these chemicals are being degraded through biometabolism by microorganisms indigenous to the groundwater aquifers or that the chemicals are being adsorbed to the materials of the aquifer matrix. If the removal mechanism is adsorption, operation of an ASR over a long enough period of time may saturate the adsorptive capacity of the aquifers, at which point extracted water will again contain these compounds at levels comparable to those in the injected water.

The studies cited in these papers show variability from location to location, based on groundwater chemistry. They also indicate that continued formation of THMs in the aquifer is theoretically possible and has been observed at some sites. Site-specific tests would be needed to determine whether degradation is occurring for the variety of constituents of concern in the treated source water and to determine degradation rates.

Current Regulatory Status

Central Valley Regional Board Involvement

In April 2003, the Board adopted, as an uncontested item, a conditional waiver of WDRs for the testing phase of a new ASR project for the City of Roseville. Because treated and chlorine-disinfected water will be injected, the waiver requires monitoring to determine potential aquifer degradation by disinfection byproducts, including THMs. The City of Tracy has requested a similar waiver for testing an ASR system that will also utilize treated and chlorine-disinfected water. Staff has prepared a tentative waiver that will permit two rounds of injection and extraction; the staff report for this waiver is part of this agenda item. The Tracy waiver proposes monitoring to determine whether THMs and HAAs remain in groundwater after conclusion of the test. Both the Roseville and Tracy ASR projects use existing drinking water treatment systems and water supply piping.

The Board has not yet been asked to approve long-term implementation of an ASR project. Unlike the proposed Tracy test, in which 200% of the injected water will be extracted, there is no assurance that injected water will be fully extracted during long-term implementation of ASR projects. Even with complete extraction, there is the potential that certain constituents will remain in the groundwater at concentrations above background and above water quality objectives.

To this point, discussion between staff of our Non-Chapter 15 (WDRs) Program have concluded that regulation of conjunctive use projects should be of a low priority, given the severe funding constraints. Several spreading basin projects, using un-disinfected high quality water from the Friant/Kern Canal, have not been regulated at all by the Board because water quality is not an issue. However, a spreading basin project proposed by the Army Corps of Engineers would use water from creeks dominated by agricultural tail water, and because staff is concerned about groundwater pollution by pesticides, fertilizers and salt, a Report of Waste Discharge was requested (but not yet received). A proposed project near Madera using Delta Mendota Canal water was withdrawn after opposition from local farmers, who were concerned that their high-quality groundwater, a source of irrigation supply, would be degraded.

Regulation by Other Regional Boards

According to the City of Tracy's consultant, many ASR conjunctive demonstration projects, and several full-scale projects, exist in other Regions. Staff asked the Non15 program managers of other Regions whether they are aware of the projects and if any are regulated. Most program managers are unaware of the projects or considered them a low threat to water quality. We are aware of only one project, in

Region 6 near Victorville, which a Regional Board is actively regulating. The project is similar to that being tested in Roseville and Tracy. Region 6 issued WDRs for the test phase, and will be considering a waiver for the full-scale project at its September 2004 meeting.

It is noted however, that the Basin Plan of only one other Regional Board (Region 8) contains the same narrative toxicity objective as does the Central Valley Regional Board's Basin Plans. As discussed above, without the toxicity objective, staff of many other Regions would compare the concentrations of constituents of concern in the injected water against the respective MCLs for the groundwater. However, it has been the practice of the Central Valley Region, even before the adoption of the groundwater toxicity objective, to cite health-based limits as being protective of beneficial uses in the long term. Using THMs as an example, the MCL for total THMs is 80 ug/l. The City of Tracy's treated drinking water contains approximately 50 ug/l total THMs, so injection into the groundwater would not exceed the MCL. In most Regions, the injection would not be a violation of water quality objectives. But Region 5's Basin Plan requires the use of toxicity-based limits, which in the case of the individual THMs range from 0.27 ug/l to 4 ug/l, so the injection of the City of Tracy's drinking water is a violation of this Region's water quality objectives. This difference in Basin Plans may explain why the other Regional Boards have little regulatory involvement in ASR projects.

State Board Involvement

The State Board Non15 program manager, Gordon Innes, has indicated that the State Board does not intend to develop a general order for ASR or spreading projects.

Regulatory Considerations

Balancing Water Quality Threats with Water Supply Enhancements

The Regional Board must balance opposing issues in the regulation of ASR projects – compliance with the Basin Plan, including water quality objectives for groundwater, and at the same time not unduly discourage conjunctive use.

To Regulate or Not

WDRs are appropriate to regulate the discharge of "waste." The Office of the Chief Counsel and the Office of the Attorney General have issued opinions that conclude that activities that result in the discharge of waste even if that is not the primary purpose of the activity is subject to regulation under the Porter-Cologne Water Quality Control Act. ASR projects which utilized injected water of higher quality than the groundwater would pose no threat to water quality, and therefore would cause no waste discharge, so the activity would not be regulated by the Regional Board. However, it is the ASR projects that utilize injected water that is of poorer quality than the underlying groundwater, and therefore inject a waste, that are the subject of this discussion.

Antidegradation

State Water Board Resolution No. 68-16, *Policy with Respect to Maintaining High Quality Waters of the State*, requires a regional board in regulating the discharge of waste to maintain high quality waters of the state (i.e., background water quality) until it is demonstrated that any change in quality will be consistent with maximum benefit to the people of the State, will not unreasonably affect beneficial uses, and will not result in water quality less than as described in applicable water quality control plans and policies (e.g. violation of any water quality objective). The policy also requires discharges to high quality waters to meet waste discharge requirements that will result in the best practicable treatment or

control (BPTC) of the discharge necessary to assure that pollution or nuisance will not occur and the highest water quality consistent with maximum benefit to the people will be maintained.

Application of Resolution No. 68-16 is a primary issue with ASR projects. Storage of surplus water for later use provides a benefit. Where should the Regional Board apply concerns over degradation – at the injection point or at some distance away? For a test phase which proposes to extract more water than was injected, how much monitoring is appropriate? Monitoring is needed to show how much degradation in aquifer water quality will occur during the test and to project water quality impacts from full-scale implementation of the ASR project.

Consistency with Other Regional Board Programs

The Regional Board has taken enforcement action against several dischargers (e.g., Georgia Pacific, All Pure Chemical, Triple E Packing) for polluting groundwater with chloroform, one of the individual THMs. There may be a significant contradiction between mandating cleanup and abatement when one set of dischargers releases a disinfection byproduct into the groundwater, while permitting another discharger to inject significant amounts of the same waste constituent into the groundwater through an ASR project. Georgia Pacific in Tracy is being required to clean up chloroform in groundwater to health-based levels, much lower than the MCL for THMs.

Our Site Cleanup program is also using WDRs, rather than waivers, for injection of reagents to promote in-situ pollutant degradation at contaminated sites. At these sites, the reagent itself or breakdown products of the original pollutant exceed water quality objectives causing temporary pollution of the groundwater. However, this pollution is justified as it is of limited aerial extent, for a limited time, and necessary to cleanup existing pollution. These Site Cleanup WDRs require monitoring of the full nature of potential groundwater impacts, and require that the Discharger implement a Contingency Plan if the polluted groundwater spreads beyond a specified area or persists within that area. Site Cleanup program decisions adhere to the Basin Plan language that applies water quality objectives throughout the aquifer; and for this reason, alternative compliance points or dilution with the aquifer are not considered in cleanup decisions. (See Basin Plan Point of Compliance, below)

In the Cleanup and Abatement Order against Mather AFB for polluting groundwater with chlorinated solvents, the Regional Board used health-based water quality limits, significantly lower than MCLs, as triggers for requiring the Air Force to provide alternate water supply when municipal wells were impacted. The local water purveyor was very supportive of this position, not wanting to be viewed as providing even small amounts of pollutants to their customers. The Drinking Water Branch of DHS also supported this decision.

The NPDES program regulates the levels of three trihalomethanes in surface waters so that these chemicals do not exceed their respective 1-in-a-million cancer risk levels specified in the California Toxics Rule. Effluent limits associated with these protections are causing many municipal dischargers to consider disinfection methods, such as UV, that do not cause the formation of these disinfection byproducts.

Basin Plan Point of Compliance

The *Policy for Application of Water Quality Objectives* contained within both the Sacramento River and San Joaquin River Basin Plan and the Tulare Lake Basin Plan states that "…Water quality objectives apply to all waters within a surface water or groundwater resource for which beneficial uses have been

designated, rather than at an intake, wellhead, or other point of consumption." Strict application of this policy requires that the entire groundwater resource not contain constituents at concentrations greater than water quality objectives. In the case of ASR projects, this means even at the point of injection into the aquifer. However, the City of Tracy has told staff that they will not be able to meet this condition at the point of injection or for some radius beyond that point. The City has asked that it be allowed to pollute within a known, controlled area. The proposed waiver (the second part of this Agenda Item) for the City's demonstration project is similar to the Site Cleanup WDRs, in which pollution is allowed for a short term, controlled project. Staff is proposing that, under controlled circumstances, it is acceptable to pollute the groundwater during a short-term test project, in order to collect the data necessary to design a long-term project. However, staff proposes that the long-term project would need to comply with State Board Resolution No. 68-16 and the Regional Board's Policy for Application of Water Quality Objectives.

Options for Removing Contaminants of Concern

Optimizing Source Water Quality

Source water for ASR projects can vary considerably. For the proposed Tracy ASR project, source water is from the Delta-Mendota Canal, which draws water from the Delta. While the City's drinking water facility is regulated by DHS and the treated drinking water meets Title 22 standards, water available from the Delta-Mendota Canal is relatively rich in organic contaminants. Discharges of agricultural and urban runoff, and treated municipal and industrial wastewater add an array of contaminants to Delta waters. Disinfection, in combination with organic contaminants, can form additional constituents of concern. If the City is required to reduce the disinfection byproducts in the water used for its ASR project, it could consider withdrawing water only during the periods when the quality of the Delta-Mendota Canal water is optimal.

Treatment Prior to Injection

Should treatment be required prior to injection into the ASR well to remove disinfection byproducts and other constituents of concern that may be present in source water? Granular activated carbon (GAC) and air stripping are proven technologies for removal of organic contaminants that may threaten groundwater quality. ASR project proponents have raised concerns regarding cost of treatment and treatment efficiency at the low constituents concentrations. Changes required for ASR systems that have already been constructed will be more costly than if these issues are addressed during early project planning phases.

Alternative Disinfection Methods

Should alternative disinfection methods (e.g., using ozone or UV) be required to reduce the formation of disinfection byproducts? So far, ASR projects proposed to use existing municipal drinking water disinfection systems, involving chlorination. Project proponents claim that disinfection is needed to prevent bio-fouling of injection wells. Concerns have been raised about the cost to modify a drinking water facility to use an alternative disinfection system. Another option would be to use alternative methods to treat only the portion of the drinking water delivered to the ASR project; however, concerns have been raised that this would be costly because it would involve modifying an existing drinking water treatment and delivery system. No treatment may be necessary prior to injection where source water has low microorganism content, as the well screens may not be fouled.

Monitoring and Contingency Plans
Full characterization of the injected water is needed to determine the presence and concentrations of disinfection byproducts and other source-water constituents so that staff are able to evaluate potential groundwater impacts from injection. Groundwater monitoring before injection is needed to determine groundwater baseline conditions. Groundwater monitoring during ASR testing and full production is also needed to determine the impact of the project on groundwater quality – whether injected water and its associated wastes are causing or threatening to cause violation of water quality objectives for groundwater and whether wastes are migrating away from the storage area. An adequate number of properly placed monitoring wells is essential to verify the groundwater gradient throughout the duration of the project. Should an ASR project threaten to violate any water quality objective, contingency plans should be included, similar to those required of reagent injection for in-situ degradation of wastes at contaminated sites.

Recommendations

The purpose of this Information Item is to ask the Regional Board to provide input as to how it will regulate conjunctive use projects in a manner that does not unduly inhibit projects designed to enhance municipal water supplies while, at the same time, providing prudent protection for groundwater quality consistent with the Regional Board's Basin Plan and other groundwater-related programs.

In providing input, the Regional Board should also consider the extreme lack of resources in the Non15 program, and the fact that regulation of conjunctive use sites will add to staff's already large workload. Currently, Non15 staff are unable to review Reports of Waste Discharge (RWDs) within the required 30-day timeframe, and are unable to review most technical reports or respond to dischargers in a timely manner. Regulating conjunctive use projects in the manner proposed below will add to the workload and lead to increased delays for all projects.

For spreading basin projects:
In general, staff will not request RWDs for these projects, and will not regulate them, unless they appear to be a threat to water quality (i.e., the Army Corps of Engineers project utilizing creeks dominated by agricultural tail water). If a threat to water quality is perceived, then spreading basin projects will be regulated as described below for ASR projects.

For ASR Projects:
Staff will request RWDs for these projects. If the discharger provides data showing that the injection will not result in a violation of water quality objectives in the groundwater, then the project will either not be regulated or regulated under a simple waiver of WDRs.

If the project description shows a potential for groundwater pollution as a result of the injection, then the project will be regulated.

Demonstration Projects will be regulated under a conditional waiver of WDRs. In general, the waiver would allow groundwater pollution for a short-term, controlled project, contingent upon (a) adequate monitoring to determine the nature and extent of water quality impacts from the short-term testing and to predict long-term impacts from full implementation of the ASR project, (b) submittal and implementation of contingency plans to clean up or abate unintended impacts on groundwater quality should the demonstration project result in violation of water quality objectives beyond the

predicted injection front or violation of water quality objectives after the injected water has been extracted.

Full-Scale Projects would be regulated in a manner consistent with State Board Resolution No. 68-16, in which it is recognized that (a) some degradation of groundwater quality by an ASR project is consistent with maximum benefit to the people of the State, (b) upper limits on allowable groundwater degradation are defined by beneficial use-protective water quality objectives, including drinking water MCLs as well as numerical limits that apply narrative water quality objectives for chemical constituents, toxicity, and tastes and odors, and (c) the degree of degradation (between background levels and water quality objectives) allowed for a particular ASR project is that which results from applying best practicable treatment or control (BPTC) measures.

The full scale project would be regulated under either WDRs or a conditional waiver, depending on the quality of the water being injected and the potential for impacts on groundwater quality. The WDR or waiver would contain conditions to (a) limit groundwater degradation consistent with water quality objectives and BPTC, (b) require periodic monitoring to determine the nature and extent of water quality impacts from long-term implementation of the ASR project; and (c) require preparation and implementation of contingency plans to clean up or abate unintended impacts on groundwater quality should the ASR project result in violation of any applicable water quality objective or degradation beyond that which results from implementation of BPTC.